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No. S-16

Accident Report

Copy No. 50

May 1958

ROHM & HAAS COMPANY

REDSTONE ARSENAL RESEARCH DIVISION

HUNTSVILLE, ALABAMA

Report No. S-16

Report of Fatal Explosion - March 28, 1958

ORDNANCE CORPS, DEPARTMENT OF THE ARMY

CONTRACT NO. DA 01-021-ORD5135

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ROHM & HAAS COMPANY

REDSTONE ARSENAL RESEARCH DIVISION
HUNTSVILLE, ALABAMA

Report No. S-16

Report of Fatal Explosion - March 28, 1958

Allen R. Deschere
General Manager

May 1958

ARMY ORDNANCE CORPS
Project Number TU2-10
RESEARCH ON ROCKET PROPELLANTS AND ROCKET MOTORS
Contract No. DA 01-021-ORD5135

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At 12:59 p.m. on Friday, March 28, 1958, an explosion occurred in a mixer bay of Building 7595 in the Rohm & Haas Company area (Fig. 1) at Redstone Arsenal, Alabama. This explosion resulted in fatal injuries to one man and in burns and cuts requiring the hospitalization of a second man.

SUMMARY AND CONCLUSIONS

A castable composite propellant of the petrin acrylate type was being processed at the time of the explosion (Table I); composition was similar to other petrin acrylate propellants which have been processed at this Division over the last several years.

Table I

Composition of QZ Propellant

Ammonium perchlorate	47.85%
Petrin acrylate	14.90
Triethyleneglycol dinitrate	17.00
Polyester P920	0.45
2-Ethylhexyl acrylate	1.60
Aluminum	18.00
Ethyl centralite	0.20

Burning rate at 500 psi: 0.5 in/sec

I^0_{1000} : 255 lb_F-sec/lb_m

The basic process used for the manufacture of these propellants was relatively simple. The plasticizer (triethylene glycol dinitrate) was placed in a heated mixer and degassed. The solid monomer, stabilizer, inhibitor, and comonomer were then added, and the mixture agitated

under vacuum until the monomer was melted. The oxidizer was added and the propellant was mixed until uniform. A polymerization catalyst was added and the propellant poured or pumped into the casing. Catalyst was either added to the propellant in the mixer or to the propellant stream between the mixer and the casing.

The unit in which the explosion occurred was a small process development setup; a larger unit for production, and a still smaller laboratory-scale unit was used for research. The process development setup consisted of a standard 10-gallon Pfaudler kettle and a small casting pit. The mixer was located in one bay of Bldg. 7595 and the casting pit was located in an adjoining bay (Fig. 2). Catalyst was added to the propellant stream between the mixer and the casting pit, and a small in-line mixer was used to disperse it throughout the propellant.

The batch being processed contained 121 pounds of propellant. Mixing had been completed and the propellant was being cast at a slow rate to determine the conditions necessary to prevent shrinkage cavities in large castings. During the casting the chemical engineer directing the experiment (Richard Meinert) was in the mixer bay to regulate the rate of casting and catalyst addition, and an operator (Charles Ivey, a laboratory assistant) was stationed in the casting bay to regulate the height of the casting bayonet. Lennon Corder, a laboratory assistant, entered the casting bay periodically to refill the catalyst burette. It was on one such occasion (after approximately one half the batch had been cast) that the explosion occurred. The propellant was apparently ignited in the in-line mixer, which was blown into five large pieces. The explosion resulted in fatal wounds to Corder; Meinert was cut by one fragment but suffered mainly from flash burns from the propellant. Meinert ran from the bay to the field

outside while Corder was blown or dragged himself to the corridor between the bay and the field. The flame propagated to the Pfaudler kettle, and the propellant in the kettle burned; the kettle lid was lifted by the pressure but was not removed from the kettle. The flame did not propagate to the partially filled casing in the adjoining bay.

An extensive investigation of the accident led to the following conclusions:

1. All personnel involved in the accident apparently followed all standard operating and safety procedures specified for this type of operation. Exposure of personnel to hazard was minimized to a point believed at the time to be reasonable, all personnel were wearing prescribed safety equipment, and no materials were present which violated safety restrictions for the bay.

2. The explosion appears to have been caused by inadequate design of the propeller shaft packing system of the in-line mixer which permitted metal-to-metal contact or pinching of propellant between the shaft and the mixer head.

3. Behavior of the propellant in the bay, previous tests of propellant stability and ignitability, and subsequent experiments to determine the temperature at which the liquid mix would ignite indicated that the particular propellant used did not introduce any hazard not present in essentially all propellant under similar circumstances. There was no evidence of detonation (shock-induced combustion) in any part of the system.

FUTURE ACTION

As a result of the accident several changes in procedure will be instituted. Those steps to be taken immediately are:

1. Redesign of processing equipment to eliminate all possibilities for frictional or metal-to-metal contact in the direct presence of propellant.

2. Redesign of processing equipment and procedures to further decrease exposure time and to increase protection of personnel during hazardous operations.

Additional action of a more general nature is also being taken to minimize hazards throughout the Division. This includes:

1. Increased emphasis in regular promotional-educational safety programs on hazards of explosives.

2. Extension of procedures for formal review of new equipment and processes to include changes more minor than those previously subjected to formal review, and also to review more often existing systems involving explosives.

3. Further extension and clarification of work order system to insure adequate attention to jobs required for safety. (Note: This matter was not involved in the incident here, but came up during a general review of safety procedures.)

4. Broader investigations of "unsatisfactory conditions" especially accidents involving explosives but in which no injury occurs.

5. Concentration on operations rather than equipment and physical conditions during safety inspections.

6. Re-examination of an awards program to recognize safety suggestions or other safety achievements.

BUILDINGS AND EQUIPMENT

Process development studies were carried out in Bays A-7 and A-8 in Building 7595 (Fig. 2). These bays have substantial 12-inch reinforced concrete walls on three sides, with a blowout wall on the fourth side. The large mixer for combining the propellant ingredients, a standard 10-gallon Pfaudler kettle, 304 stainless steel, equipped with an anchor agitator and a flush-bottom discharge valve, was set up near the center of Bay A-8. The casting pit was set in the floor of Bay A-7. A plastic hose was connected between the discharge

valve of the kettle and the in-line mixer, and another from the Sigmamotor pump passed through the wall between the two bays to the casting pit in which the motor was placed. A table set between the mixer and the north wall of Bay A-8 supported a burette used to meter the catalyst to the propellant stream, an in-line mixer used to disperse the catalyst in the propellant, and a Sigmamotor pump (Fig. 3). The Sigmamotor pump operates by the peristaltic action of mechanical fingers on the tubing which passes through it. Since petrin acrylate propellants are quite fluid and non-viscous the elevation of the mixer was sufficient to allow gravity flow of the propellant and the pump was generally used only for metering.

The in-line mixer (Figs. 4 - 7) was a cylindrical metal vessel having an inside diameter of 2 inches, length of approximately 4 inches, and a volume of approximately 10 cubic inches. The mixer was closed with an end cap held in position by two shear pins, and nipples were welded to each end to allow attachment of the hose. An impeller shaft was set into the head-end at approximately a 30^0 angle, and Teflon packings were used to prevent metal-to-metal contact. The impeller and shaft were made of stainless steel, and the interior of the mixer was lined with a Teflon sleeve to prevent metal-to-metal contact between the mixer and the impeller if the impeller shaft should become malaligned. In the original design of the in-line mixer the packing around the impeller shaft was tightened by screwing the gland into threads in the mixer head. However, an overheating had been noted at one time and there was also the possibility that propellant could enter the threads. Therefore, for safety, the male threads were cut off and two brackets attached by small screws to opposite sides of the hexagonal outer surface of the gland. One brass screw was inserted in the protruding part of each bracket and the gland tightened by screwing into blind threaded holes in the mixer head.

GENERAL DESCRIPTION OF PETRIN ACRYLATE PROPELLANT BATCH NO. QZ_s-15 AND EXPLOSION

Propellant Batch No. QZ_s-15 was one of a series of batches being made to determine the conditions necessary to prevent the formation of shrinkage cavities in large castings. The experiment was under the direct supervision of Richard Meinert, a chemical engineer, who was assisted by Lennon Corder and Charles Ivey.

The casting technique and casting rate for this particular batch were designed to maintain a constant liquid level above the gelled surface of the propellant. The mixing technique was not being investigated, and with one exception the standard method used to mix several thousand pounds of propellant was used for this batch. In the standard method the mixing temperature was decreased from 175°F to 150°F after the monomer melted, primarily to increase the pot life of the propellant. However, for this series the batch temperature was maintained at the curing temperature of 170°F during the casting operation to equalize the curing rate in the motor. One compositional change was made: the inhibitor level was decreased from 0.02% to 0.005% (based on total monomer) to decrease the gel time. Both of these changes had been made in previous batches.

The mixing operation was normal in every respect (the standard mixing procedure is given in Appendix A.) After completing the mixing operation and deaerating the batch in the mixer, the agitator speed was decreased from 125 rpm to 85 rpm to prevent settling of the solids. Meinert entered the mixing bay to control casting rate and Ivey handled the casting bayonet in the adjoining bay. Corder was stationed at the control panel in the operating corridor, but occasionally entered the mixing bay to assist.

At 11:17 a.m., casting was started. A small amount of

propellant was cast into an ice cream carton to insure that the equipment was operating satisfactorily, and the casting bayonet was then placed in the casing. The casting operation was continued without change until 12:45 p.m. when the casting rate was found to be too low to maintain the desired level of unpolymerized propellant. The pump speed was increased from 85 rpm to 126 rpm and the catalyst rate was increased a corresponding amount. During the entire casting operation, the propellant appeared normal. At 12:59 p.m. there was an explosion in the bay at which time the casing contained approximately 40 lbs. of propellant and the kettle contained approximately 70 lbs.

Corder had just entered the bay to help refill the catalyst burette and both Meinert and Corder were standing in front of the catalyst burette (Fig. 2). Meinert was apparently standing to the south and was probably turned partially toward Corder who was probably facing the table almost directly. They stood within two feet of the in-line mixer, though their attention was on the burette in front of the mixer.

The explosion apparently started in the in-line mixer and blew this into five large pieces (Figs. 8 & 9), one of them consisting of the upstream mixer head and the other four almost symmetrical longitudinal fragments of the downstream mixer body. A loud report and bright flash with a spray of burning propellant occurred almost simultaneously. Flying fragments of this mixer and neighboring parts (Fig. 10), such as a hose clamp apparently from one end of the mixer, caused fatal wounds to Corder, while Meinert was cut by a fragment but suffered mainly from flash burns from the spraying propellant.

Meinert ran from the bay to the field outside while Corder was blown or dragged himself to the corridor between the bay and the field.

Fifteen to thirty seconds after the explosion, a large but less

sharp boom was heard, most likely from the release of the top of the 10-gallon kettle into which the flame probably propagated from the bottom outlet. This vessel, though lidded, was vented; the pressure buildup caused the lid to break its few fastenings and rise but the lid with its agitator and drive stayed on top of the kettle (Fig. 11) while the room filled with flame and smoke from this kettle and from propellant sprayed out the top of it.

The second blow apparently pushed Corder out of the door (Fig. 12) between the corridor and the field.

One or more lighter blows were heard later by some observers, perhaps from the vacuum trap on the kettle or other sources. The hoses on either side of the pump burned, but neither the hose through the wall nor the section in the pump ignited. The pump happened to be in a condition where the fingers had both ends of the hose in it sealed off. No part of the blast or fire propagated to the casting pit (motor) bay (Fig. 13) or to the control area in the west corridor (Fig. 14).

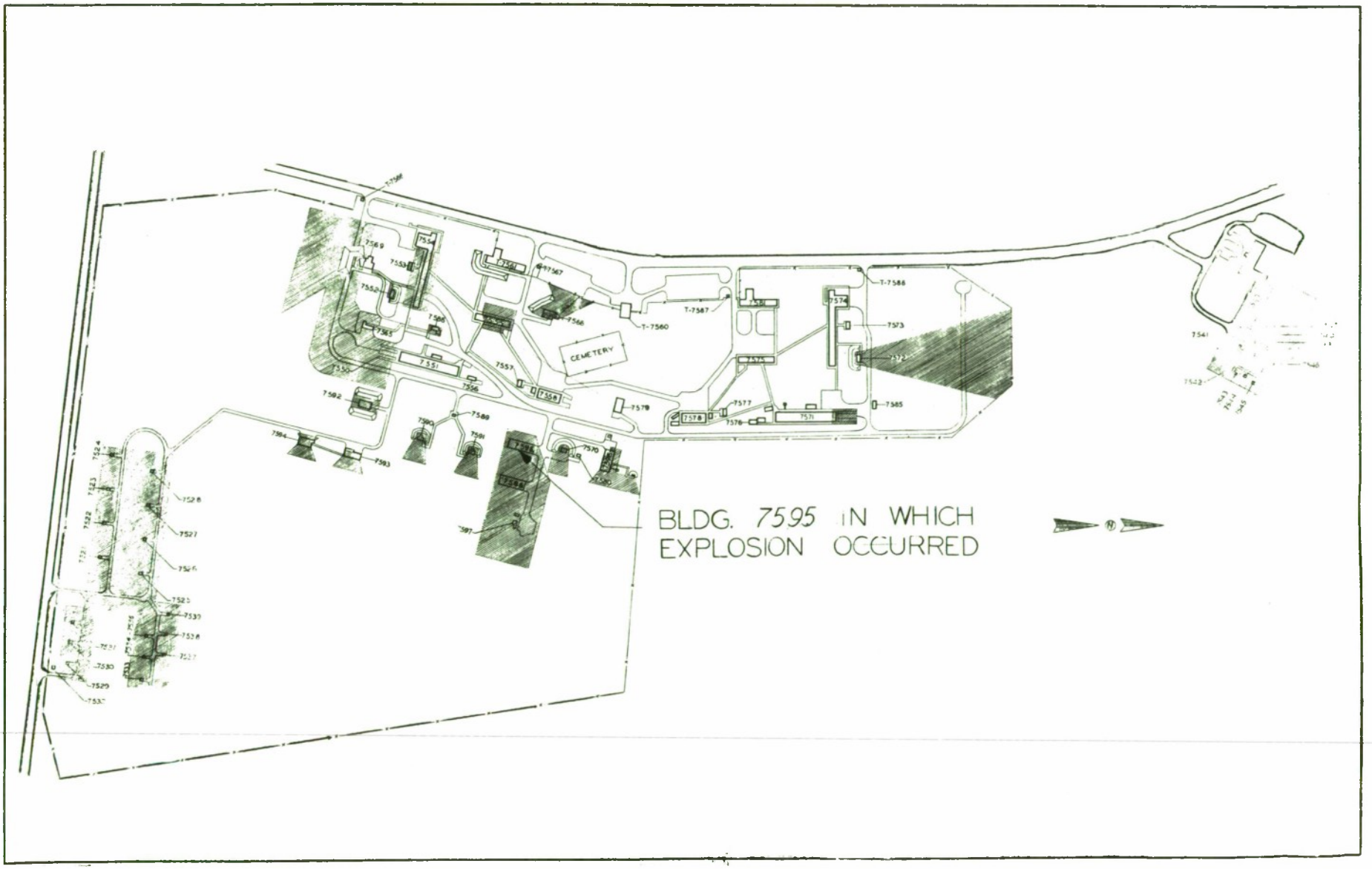

Fig. 1 Plot plan of area occupied by the Redstone Arsenal Research Division. Shaded portions represent hazardous areas to which access is restricted; they are not inter-line distances.

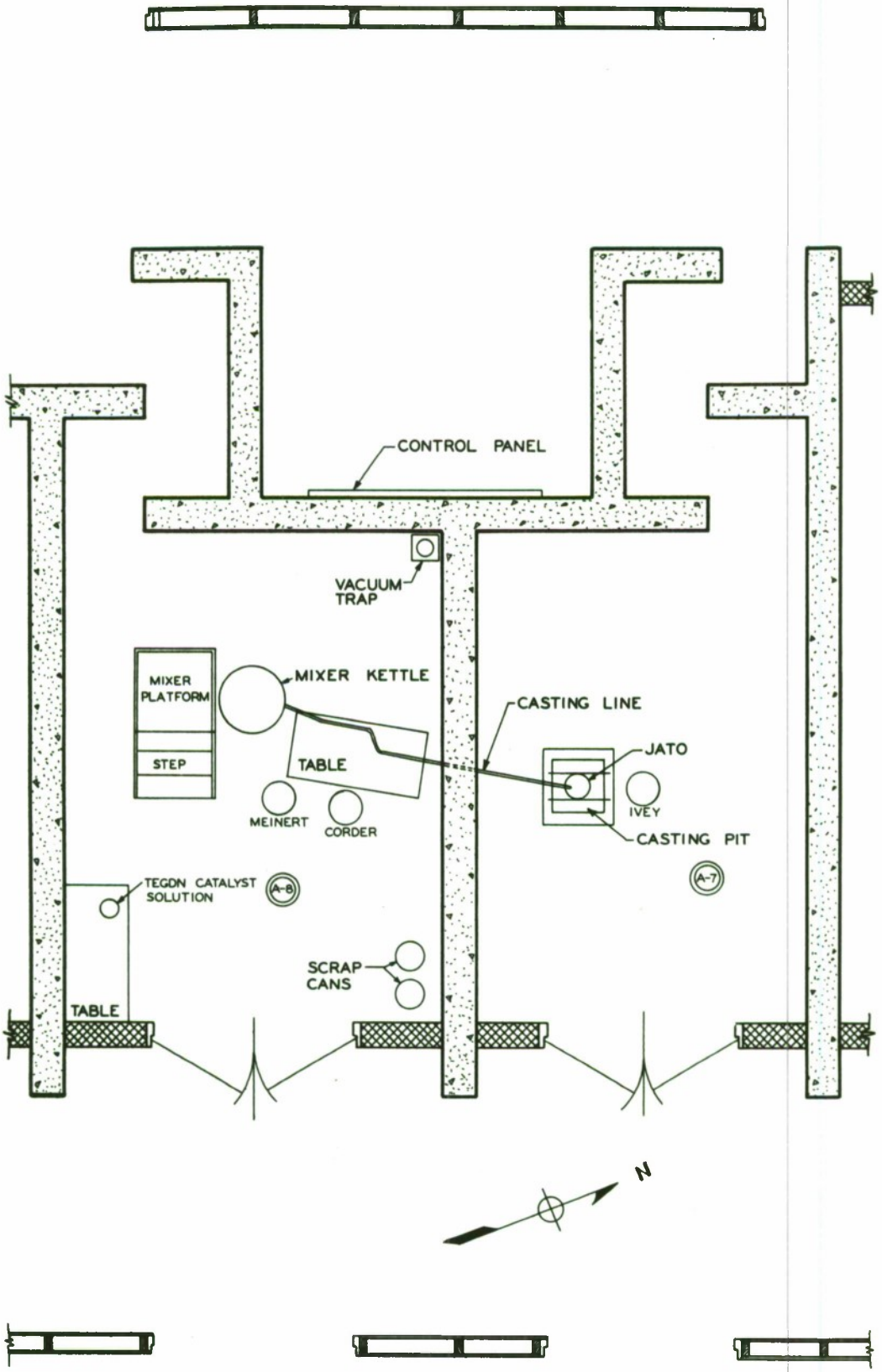

Fig. 2 Floor plan of bays A-7 and A-8 in Bldg. 7595.

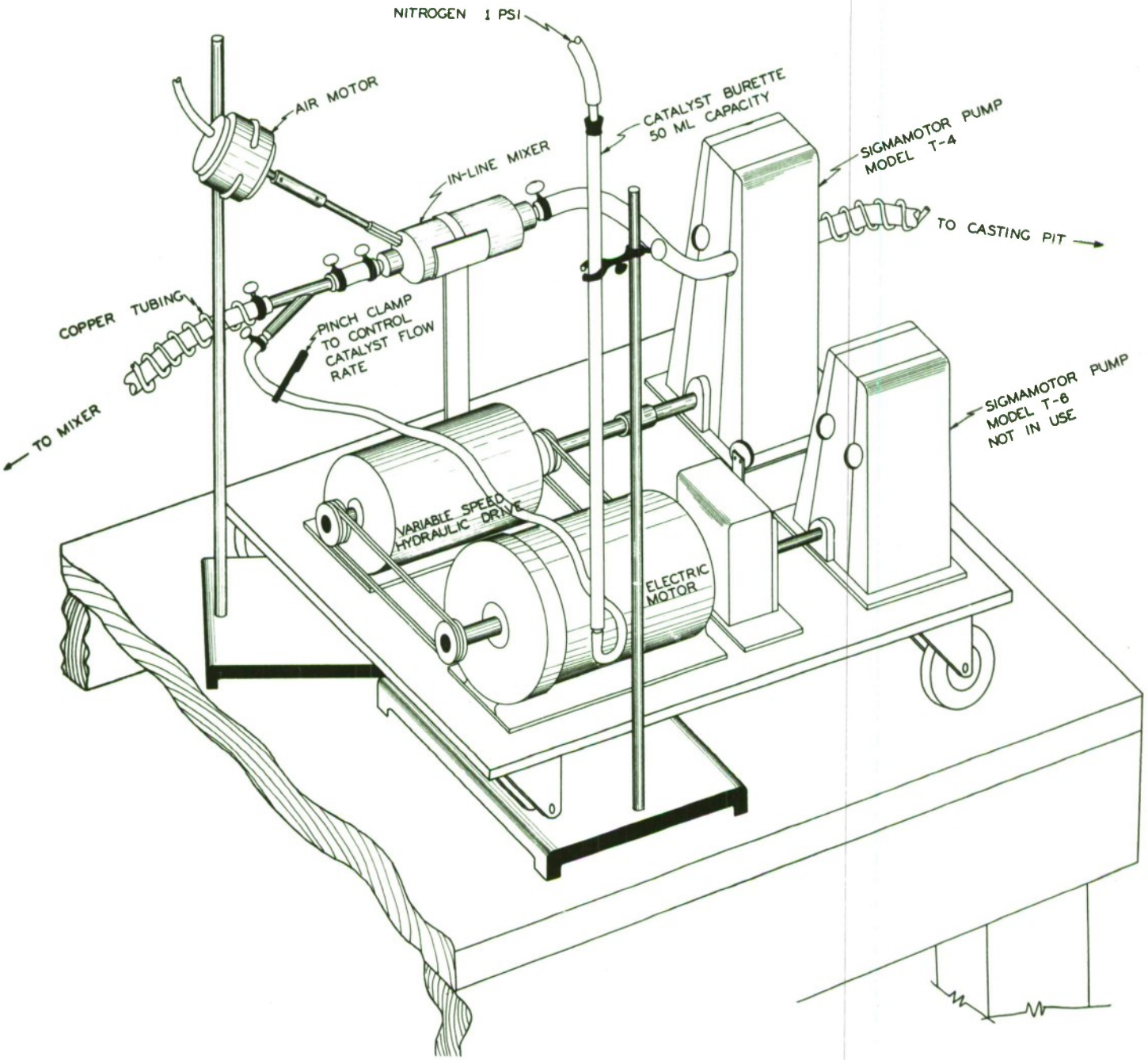

Fig. 3 Isometric of table top showing catalyst burette, in-line mixer, and Sigmamotor pump.

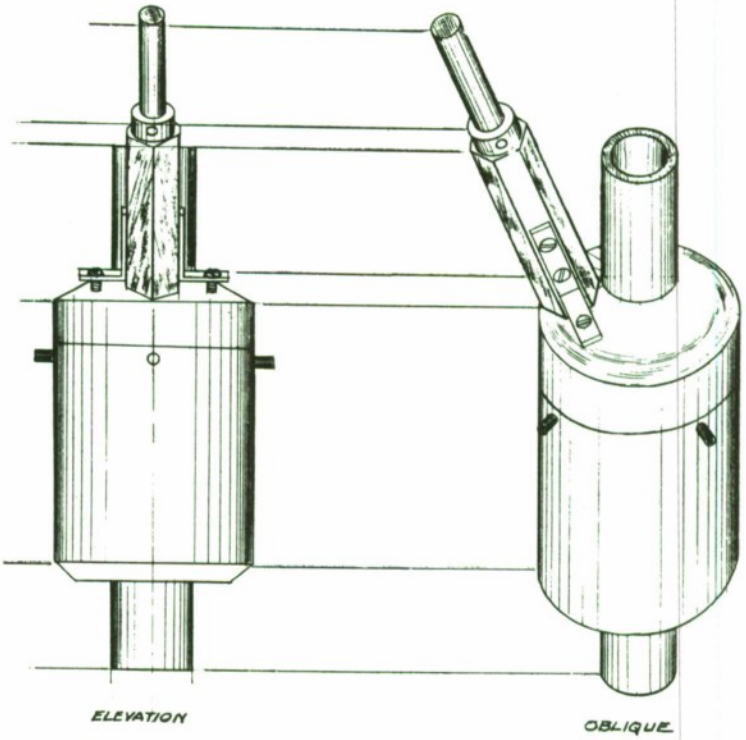

Fig. 4 External views of modified in-line mixer.

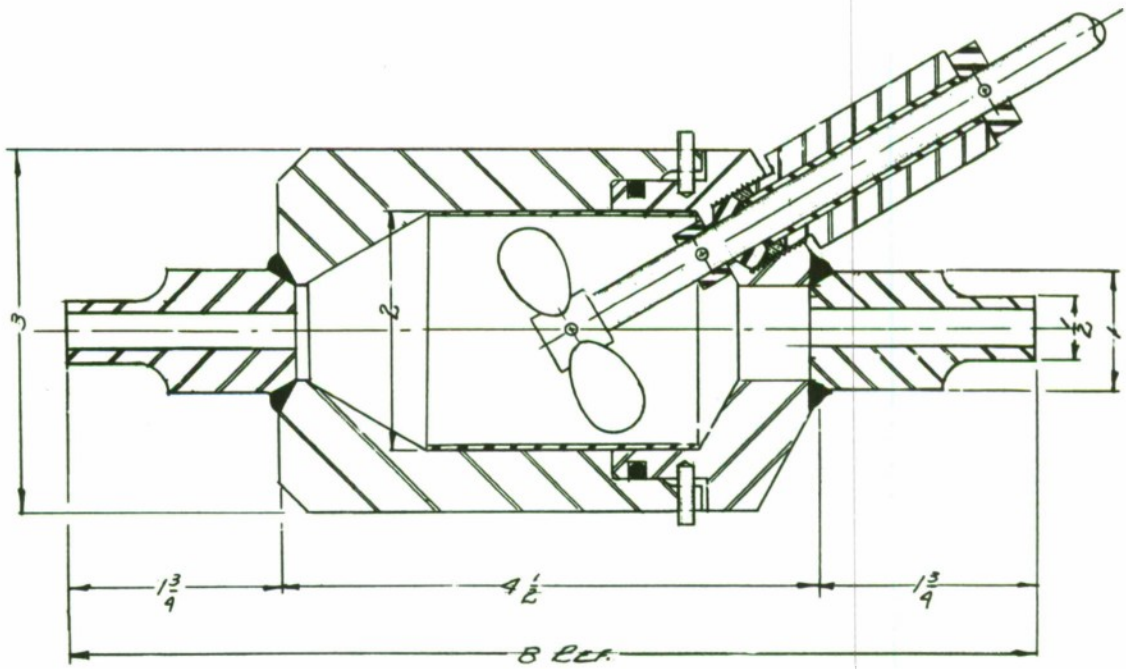

Fig. 5 Cross-section of modified in-line mixer.

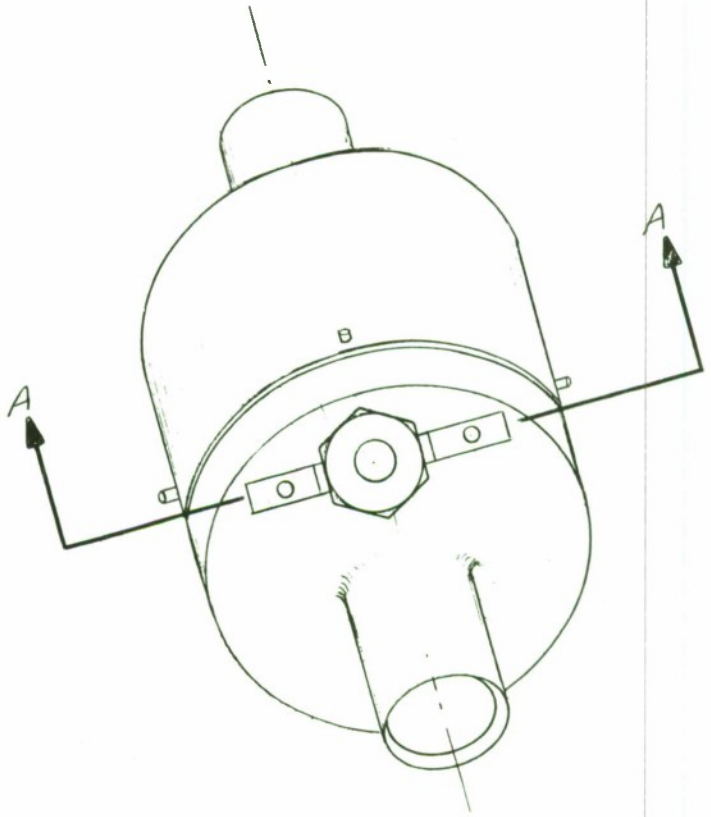

Fig. 6 Oblique view of modified in-line mixer.

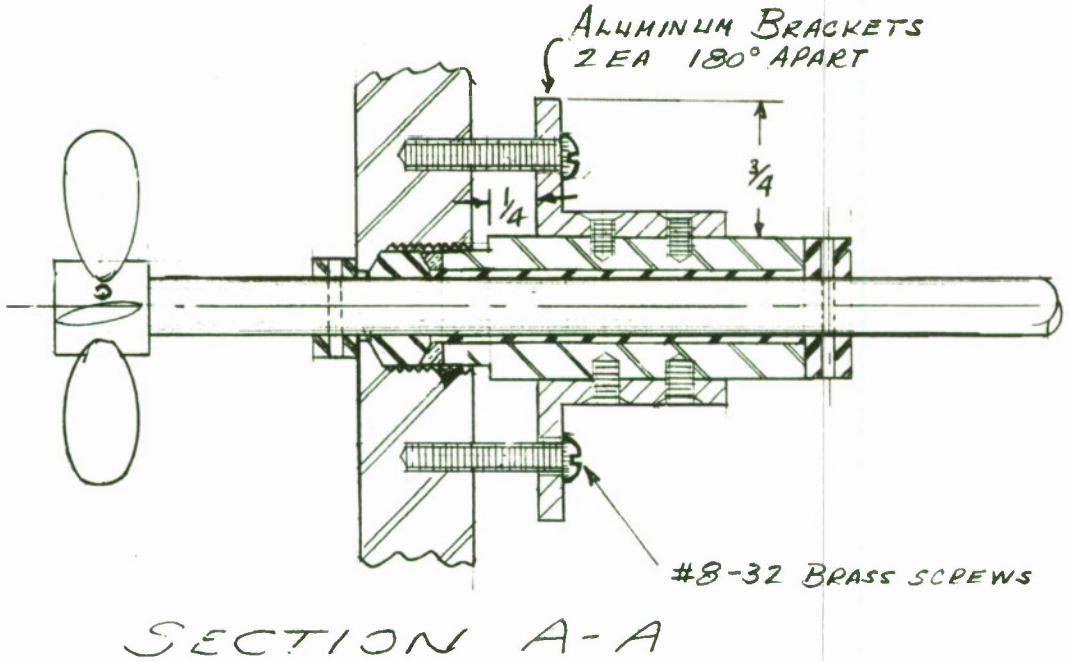

Fig. 7 Shaft cross-section of modified in-line mixer.

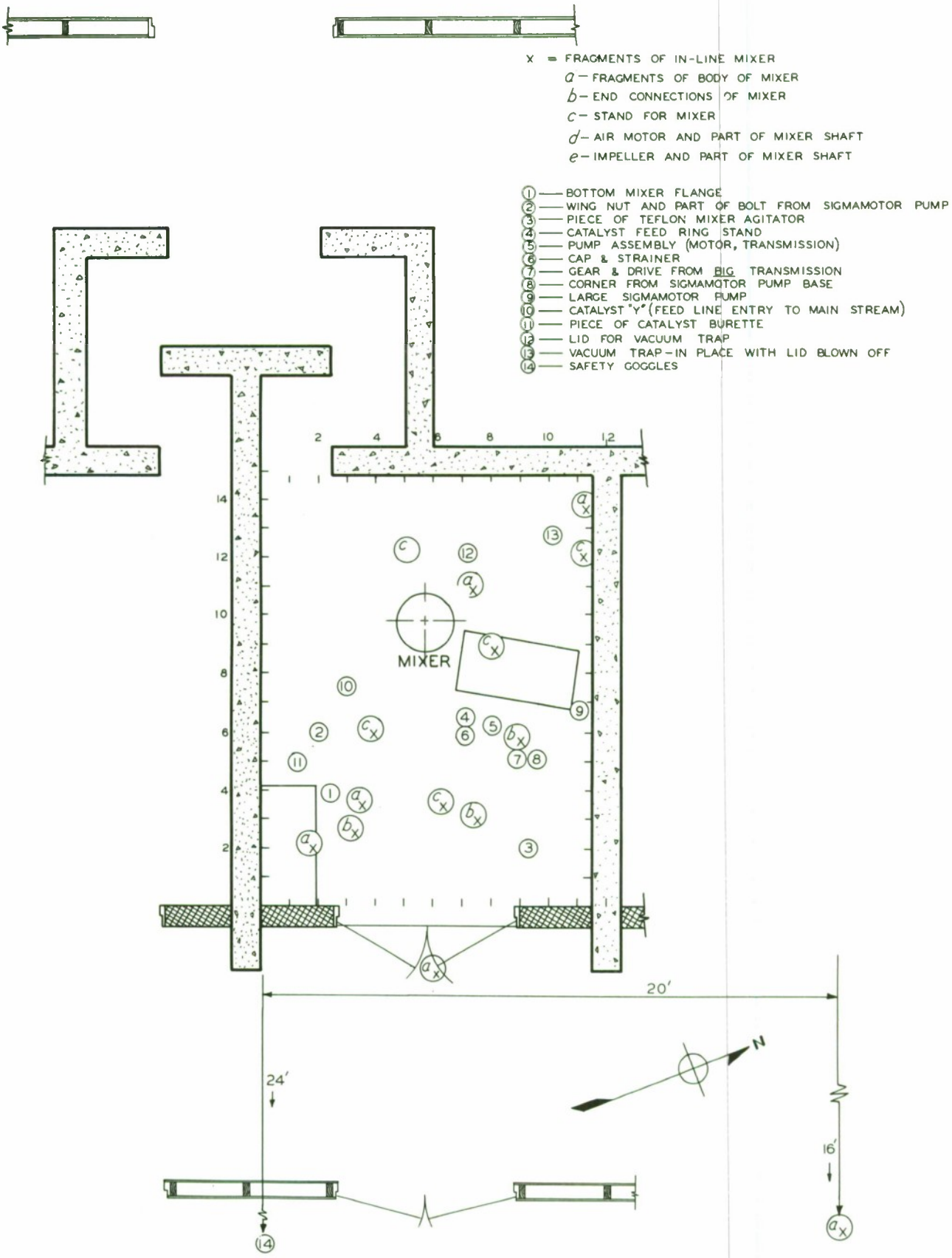

Fig. 8 Floor plan of bay A-8 showing location of fragments

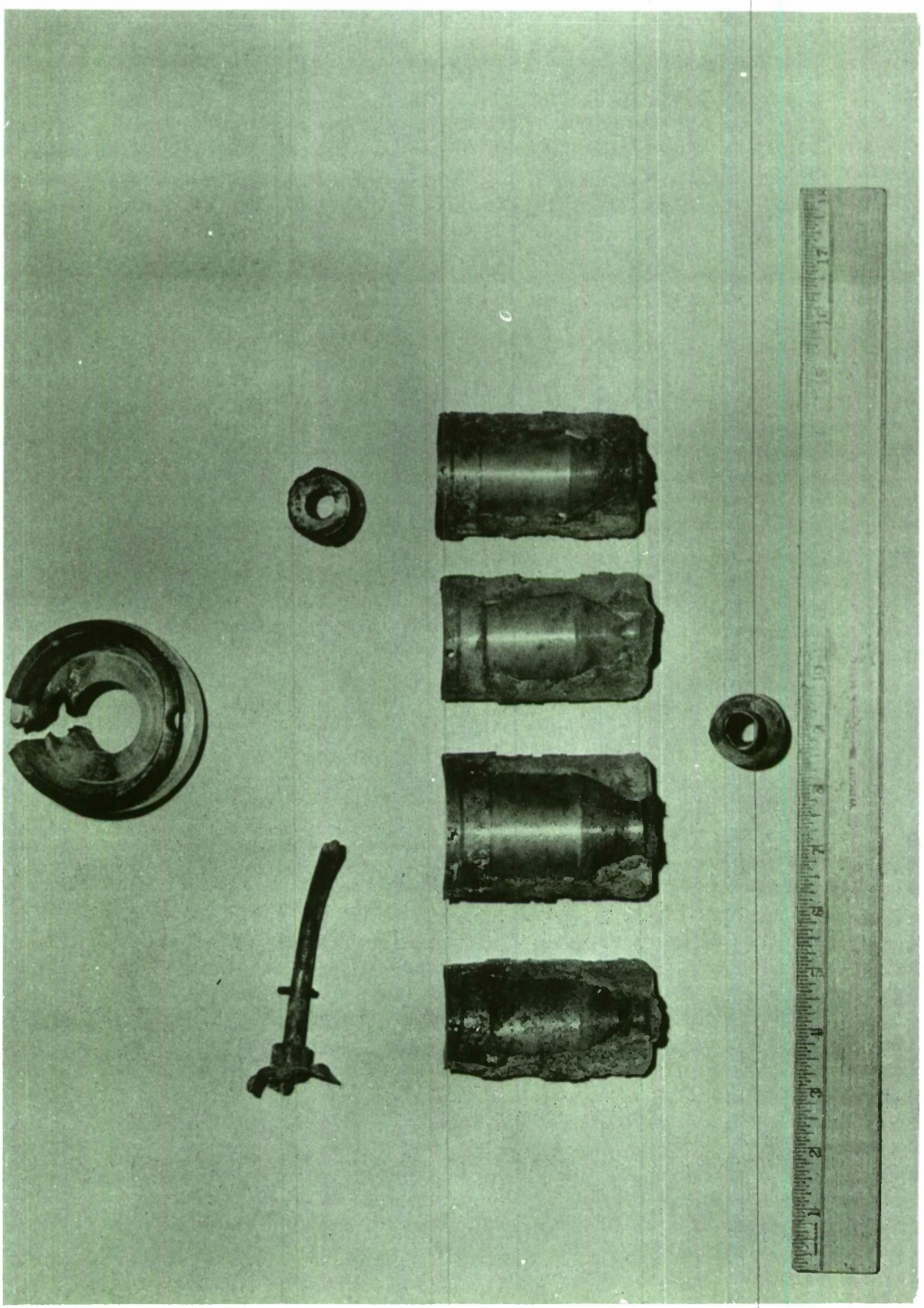

Fig. 9 Pieces of in-line mixer body recovered after the explosion.

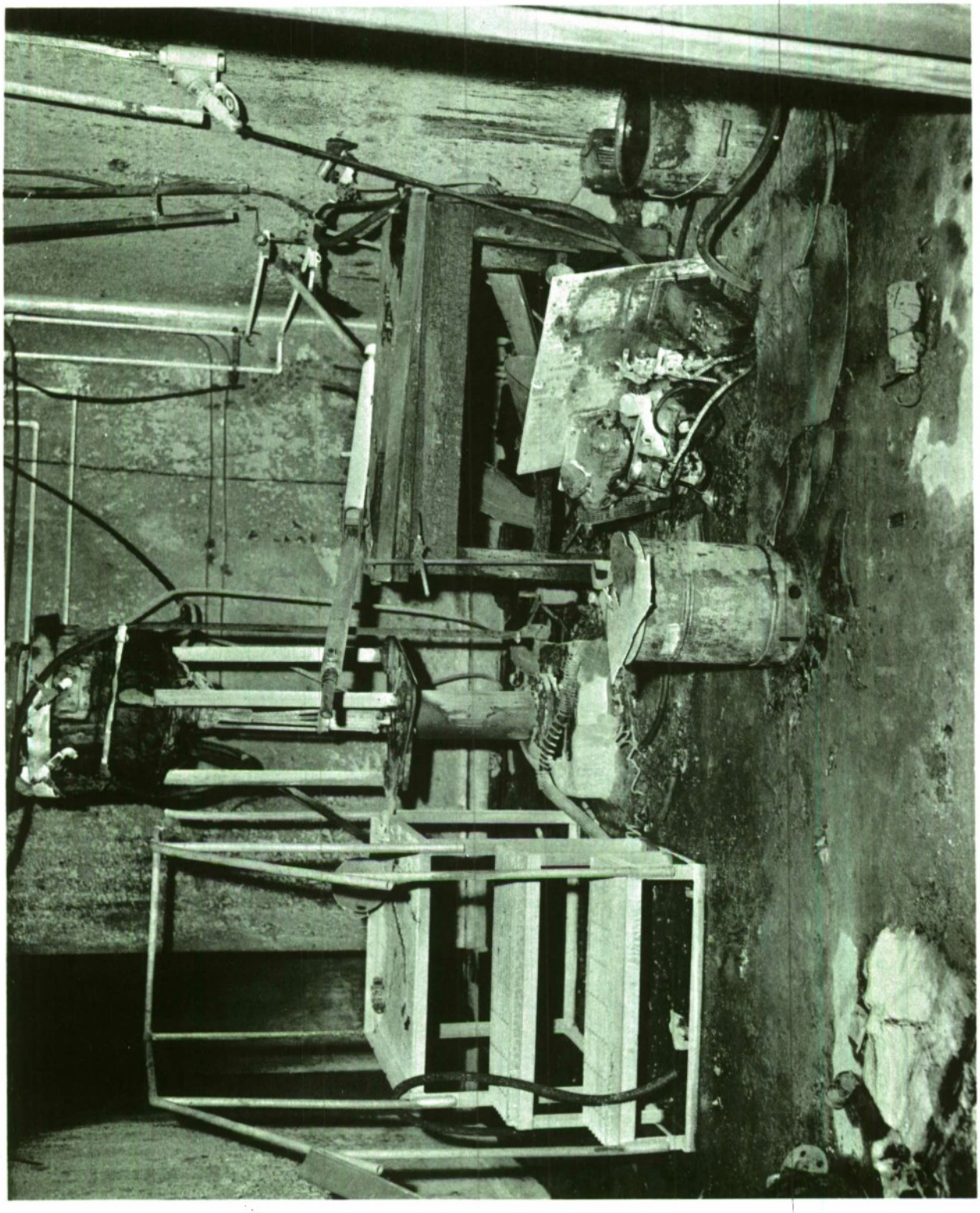

Fig. 10 General view of Bay A-8 following the explosion.

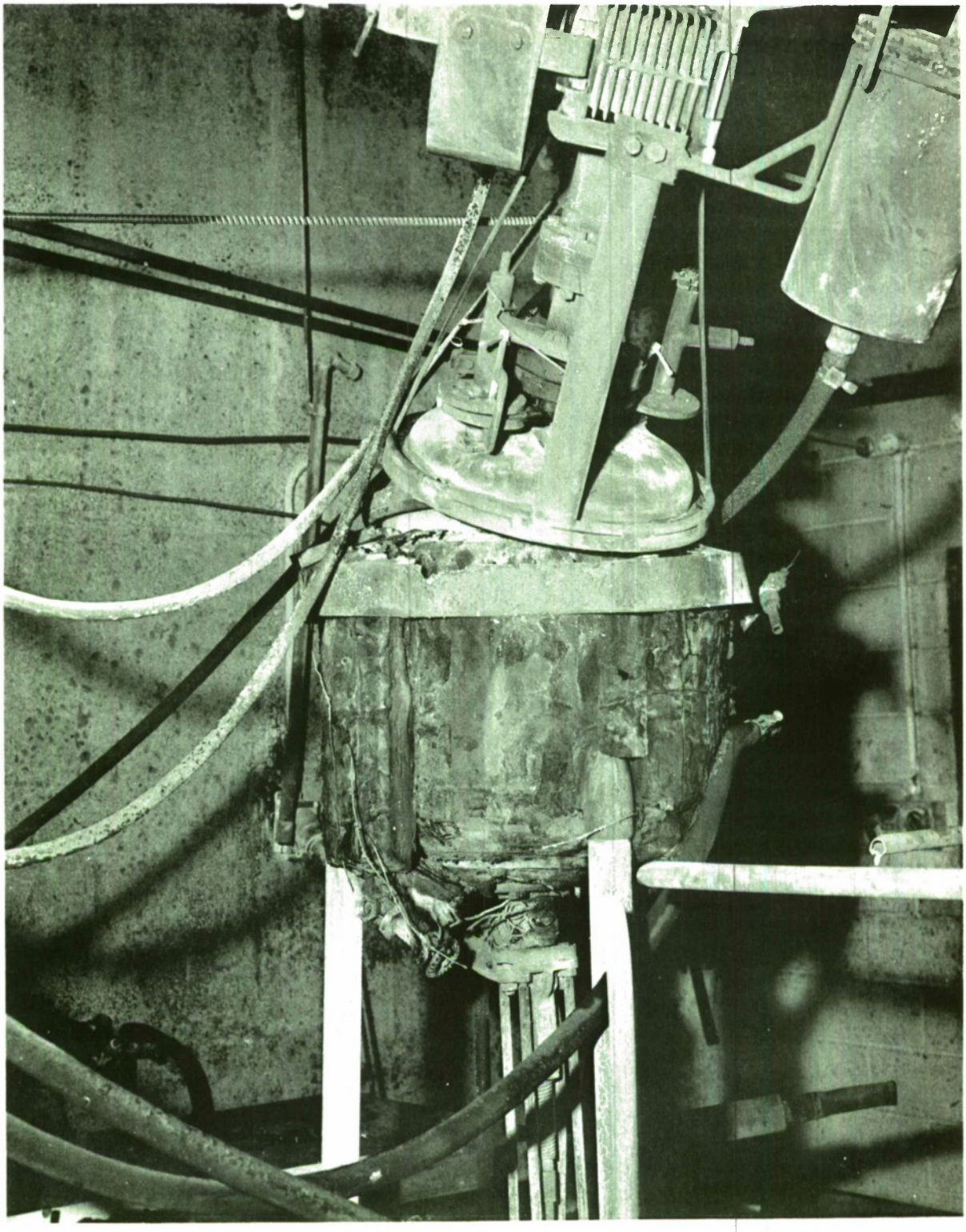

Fig. 11 Mixer kettle after explosion.

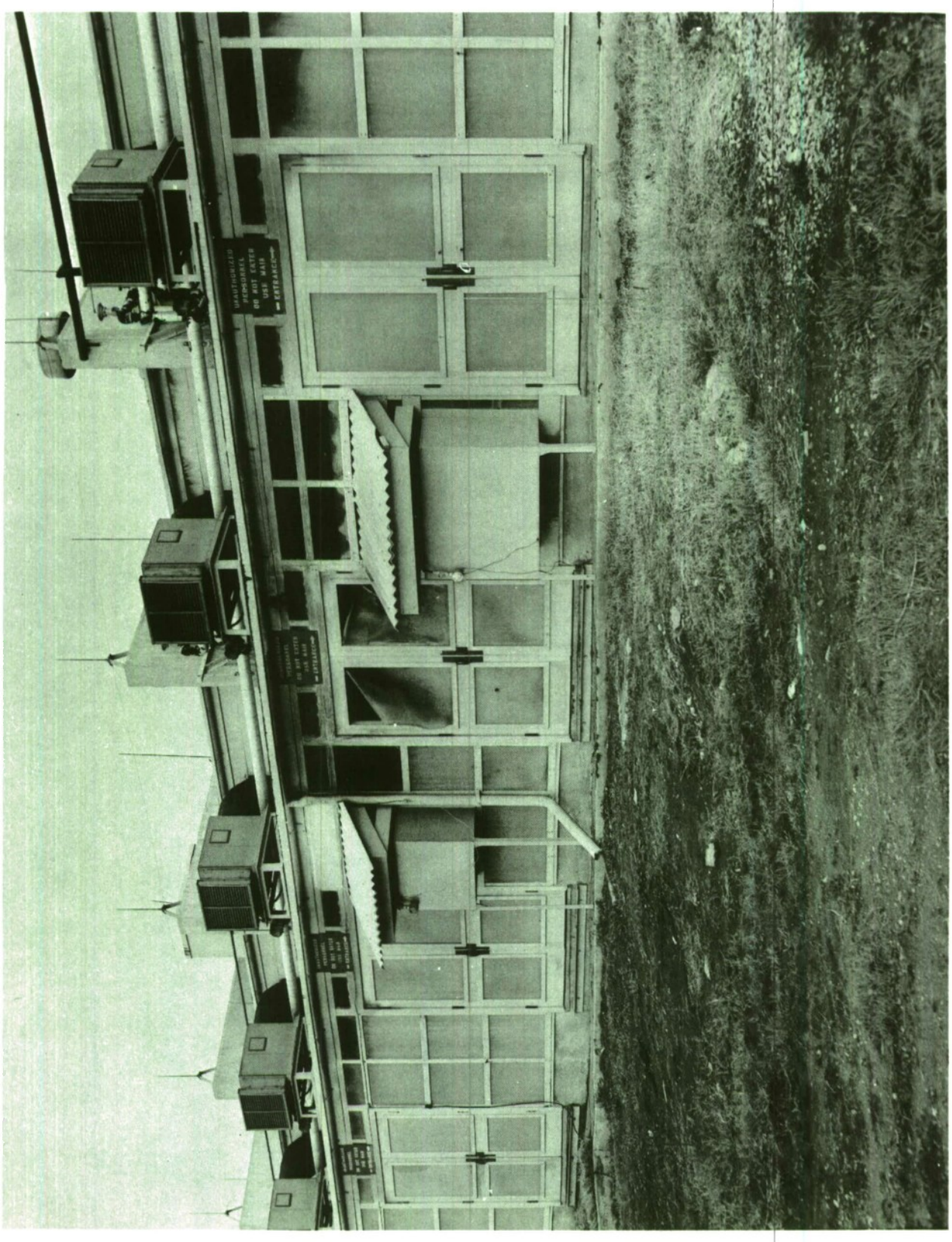

Fig. 12 East side of Bldg. 7595. Door on which screens are torn is opposite Bay A-8.

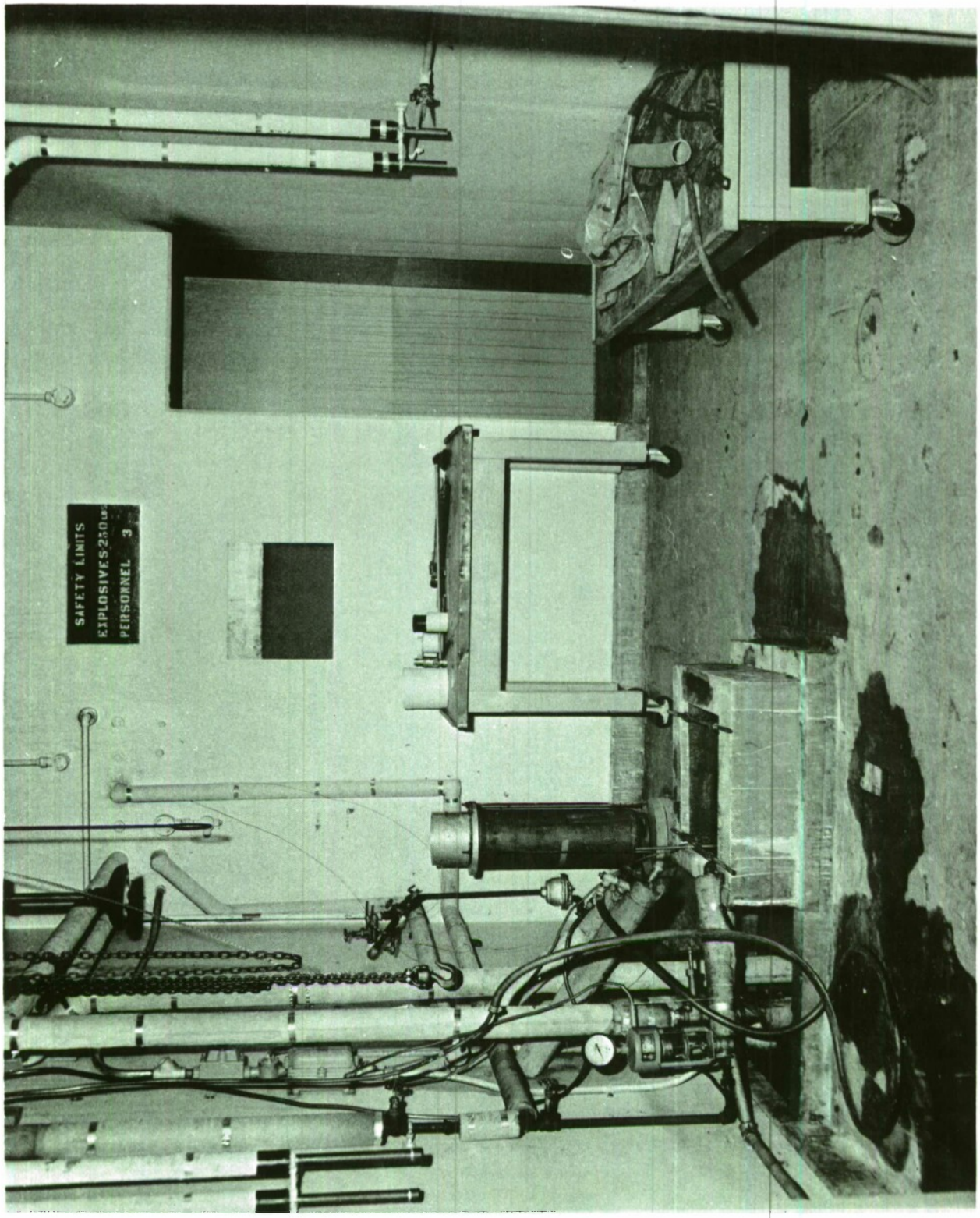

Fig. 13 Casting pit bay following explosion in adjacent bay.

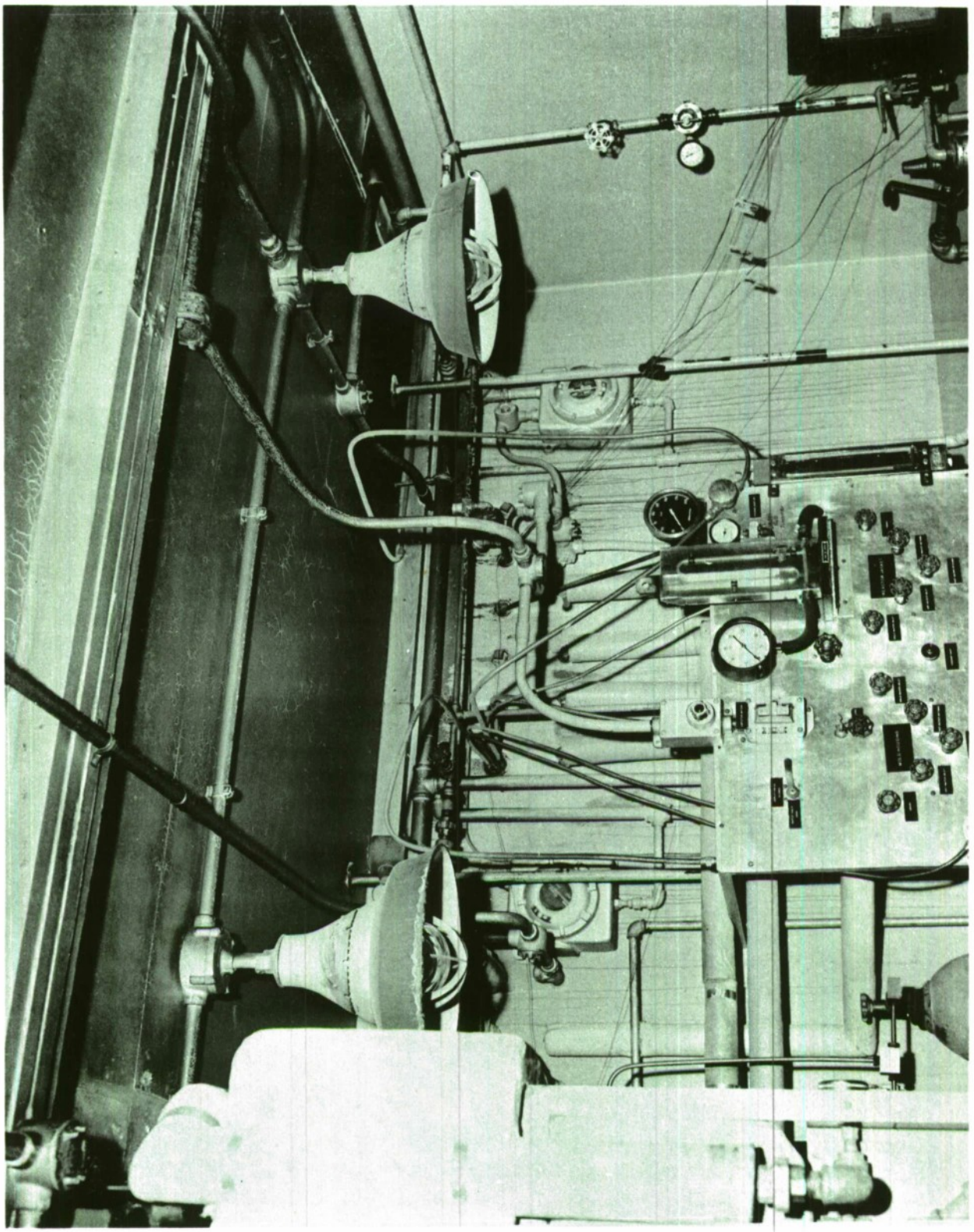

Fig. 14 Control area in west corridor following the explosion. Blackened area near ceiling was caused by smoke.

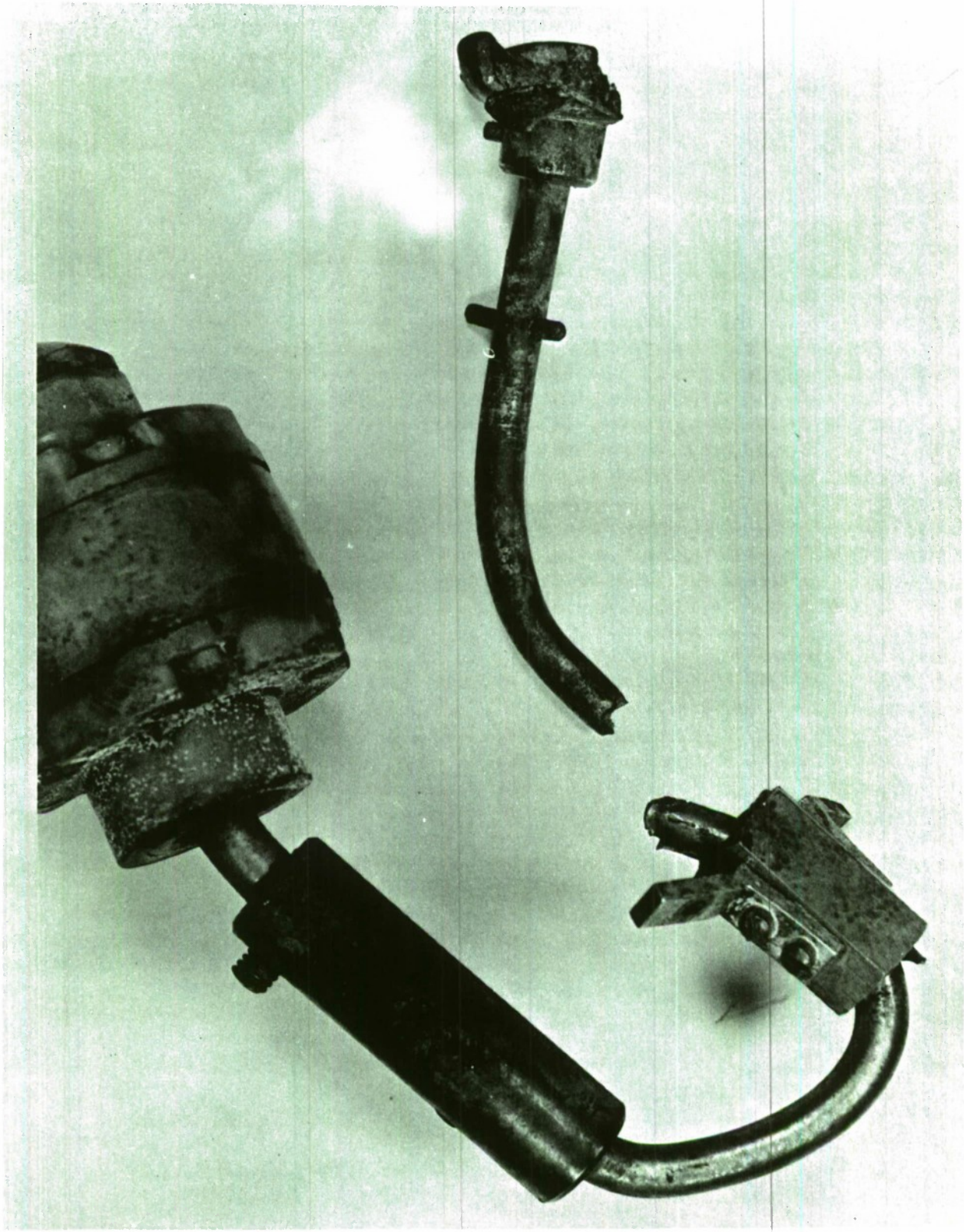

Fig. 15 In-line mixer shaft following explosion. Slight scoring can be seen above the pin near the impeller.

APPENDIX A

Revised Standard Operating Procedure for Processing Petrin Acrylate Propellant (December 5, 1957)

Effective immediately, the following processing procedure will be followed:

A. Weighing

1. Weigh correct amount of petrin acrylate monomer for batch.
2. Weigh correct amount of NH_4ClO_4 for batch.
3. Weigh correct amount of aluminum for batch.
4. Weigh correct amount of ethyl centralite for batch.
5. Weigh correct amount of 2-ethyl hexyl acrylate for batch.
6. Weigh correct amount of Polyester 920 and add sufficient amount of triethylene glycol dinitrate dilute (approximately 1:5 ratio).
7. Weigh correct amount of catalyst (t-butyl perbenzoate) and dissolve in triethylene glycol dinitrate (approximately 1:3 ratio).
8. Weigh correct amount of quinone.
9. Weigh correct amount of p-methoxy phenol.
10. Add inhibitors and ethyl centralite to petrin acrylate monomer.
11. Withdraw 50 gram sample from triethylene glycol dinitrate lot.

Note: Triethylene glycol dinitrate must be weighed in Explosive Liquids Weigh Room. 100 additional grams of triethylene glycol dinitrate must be added to batch for sample withdrawal.

B. Mixer Preparation

1. Check mixer for cleanliness and wash with acetone if necessary.
2. Check for vacuum leaks.
3. Turn on jacket water heater and set thermostat at 180^0F.
4. Close bottom outlet valve on mixer.
5. Install proper casting fixtures on mixer such as flanges, tubing, etc.

C. Mixing

1. Install safety gates.
2. Turn on recorder and allow jacket water temperature to reach 175^0F before charging.
3. Charge triethylene glycol dinitrate.
4. Start agitator. (Note: Agitator speed - 10 gal. mixer, 125 rpm
   100 gal. mixer, 60 rpm)

5. Turn on vacuum pump and evacuate to 20 - 25 mm Hg.
6. Mix for 15 minutes after 20 - 25 mm Hg. and batch temperature is above 140°F.
7. Stop agitator and release vacuum.
8. Withdraw 50 gm. sample of triethylene glycol dinitrate from mixer.
9. Charge petrin acrylate monomer, 2-ethyl hexyl acrylate, inhibitors, Polyester 920, and ethyl centralite to mixer.
10. Start agitator, mix 5 minutes. Increase agitator speed to 85 rpm on 100 gal. mixer.
11. Turn on vacuum pump and evacuate to 20 - 25 mm Hg.
12. Mix 15 minutes after batch temperature reaches 175 - 180°F. Maintain less than 25 mm Hg. pressure.
13. Turn off agitator and release vacuum.
14. Set thermostat to jacket water heater at 150° on 100 gal. mixer and 140° on 10 gal. mixer.
15. Charge catalyst to catalyst tank.
16. Check batch for unmelted monomer. (Note: Save sample if anything out of ordinary appears.)
17. Charge NH_4ClO_4 to mixer.
18. Turn agitator on and mix 4 minutes.
19. Turn on vacuum pump and evacuate to 20 - 25 mm Hg. or less.
20. Stop agitator and release vacuum.
21. Charge aluminum to mixer.
22. Turn agitator on and mix 5 minutes.
23. Turn vacuum pump on and evacuate to 20 - 25 mm Hg. pressure or less.
24. Mix 10 minutes after vacuum pressure and water temperature is reached. (140°F for 10 gal. mixer; 150°F for 100 gal. mixer)
25. Open valve to catalyst tank.
26. Add catalyst under vacuum for 3 minutes.
27. When catalyst is all in as indicated by increase in pressure, break vacuum.
28. Open bottom outlet valve and start casting.
29. Slow agitator to 80 rpm on 10 gal. mixer.

D. Casting

1. Slow agitator to 60 rpm - 100 gal. mixer; 80 rpm - 10 gal. mixer.

2. Cast into preheated (170^0F) motors.
3. Bayonet cast motors if possible.
4. Vibrate motors when casting thick compositions.
5. Vibrate mixer if necessary for flow.
6. Clean mixer with acetone when casting is finished.

E. Curing

1. Place motors in 170^0F $\pm$ 2^0 oven and cure for at least 40 hours.

Note: The SOP for the pumping operation in metering catalyst and casting using the 100 gal. mixer has not been established.

APPENDIX B

AFFIDAVIT

Mr. Richard N. Meinert, badge #RH 449, of 108 South Edgemont Circle, Huntsville, Alabama, employed as a chemical engineer by Rohm & Haas Company, Redstone Arsenal Research Division, Huntsville, Alabama, was sworn as witness and stated as follows:

"I will first describe the operation in progress at the time of the explosion. As you know this was a slower casting than usual. We were trying to get the propellant to gel in the rocket motor casing while ungelled material was being added on top of it. We were aiming for six inches of ungelled material on the top of the gelled propellant. We were casting a standard Jato unit of approximately 100 lbs total propellant weight. The propellant mix had been prepared that morning and at about 11:20 we started the casting operation. First we partially filled one ice cream carton to make sure that everything was working properly. Then we started casting directly into the motor casing. I don't know exactly when this was but it wasn't long after 11:20. The total depth of the motor casing from the top of the casting head is about 34 inches. I am told that the log states that at 12:10 we measured a depth of 27-3/4 inches to the propellant surface. This indicates that we had cast a little over six inches of propellant up to that time. We found that during this early part of the casting the propellant was gelling two inches below the surface. As I mentioned before we wanted six inches of ungelled material so we had to adjust the speed of the propellant pump - I believe we increased from 85 rpm to about 126 rpm - and we changed the rate of addition of catalyst from 2 mm to 3 mm per minute.

"The layout of the equipment within the bay is shown on Sketch A (Fig. 2) and an enlarged view of the layout of equipment on

the in-line mixer table is shown on Sketch B (Fig. 3). During the casting operation we kept the big kettle in operation at its lowest possible speed. This was done to prevent the material from settling. Propellant material was allowed to flow by gravity through a plastic line to the in-line mixer. The catalyst addition took place just prior to the in-line mixer as shown by the lines joining in Sketch B (Fig. 3). The catalyst burette was located at the front of the table and the rate of addition of catalyst could be adjusted by means of a pinch clamp. The catalyst burette was kept under about 1 psi of nitrogen pressure. The in-line mixer was driven by an air motor. This motor is not geared up in any way and produces very little torque. It could be stopped by grasping the shaft with your fingers. The in-line mixer itself had been drawn up by the Design Group of the Engineering Section from a sketch supplied by me. Its design is shown on Sketches C-1, C-2 and C-3 (Figs. 4 - 7). It had a Teflon sleeve inside to guard against the possibility of metal-to-metal contact between the inside of the mixer and the impeller and it had Teflon packing rings to prevent metal-to-metal contact with the stirrer shaft. Originally the packing ring follower had screwed into the head of the stuffing box of the in-line mixer. This permitted the assembly to be screwed in too tightly if you really bore down. When this occurred once a few days before the accident the stuffing box overheated. To correct this condition we had the Shop remove the threads and install two little shoulders which allowed the packing ring follower to be screwed to the mixer head. The modified assembly was supposed to prevent any excessive tightness in the stuffing box assembly. Also there was no longer a threaded joint in a position where there might be contact with propellant. I think the records will show that we had one run with the redesigned stuffing box before

the accident took place. I think we loaded a motor on Wednesday afternoon; we had none on Thursday. We disassembled the in-line mixer for cleaning after each run. The head fit on to the mixer by means of four pins, but only two of the pins were being used. The pins were kept in place by means of tape around the joint. Prior to this particular run, Doffus Wales had cleaned the mixer and I reassembled it myself. There had never been any signs of scoring on the Teflon sleeve from the impeller. I don't think any scoring could take place anyway because this stirrer was so weak that it would easily stall out if any resistence were met.

"The casting operation, as we were conducting it, involved a total of three men. Ivey was in the next bay handling the bayonet. I was taking care of the necessary adjustments in the mixer bay. Corder was on hand to help out when needed. In particular, it was our practice for Corder to come in and help me reload the catalyst burette. This burette only held 50 cc. Since we were adding catalyst mixture at the rate of 2-3 cc per minute, this supply would only last at most 25 minutes. We had the catalyst in a big polyethylene jug. It was made up in an 8 to 1 ratio with triethylene glycol dinitrate (8 parts TEGDN, 1 part catalyst). Originally this catalyst mixture had been made up on Wednesday with a very high dilution ratio - 65 to 1. On Wednesday, we were using the catalyst pump and we have trouble with low rates with that pump so we had the high ratio. On Friday, Corder and I made the calculations for changing the concentration of catalyst in this mixture and Corder fortified it to make it 8 to 1.

"At the time the explosion took place, Corder had just come into the bay. We were standing together at the table on which the catalyst burette is located. We were either in the process of reloading the catalyst burette or we had just finished doing it. As far as I can remember, Lennon (Corder) was standing to my right, a foot or two away.

Our positions as I remember them are marked on Sketch A (Fig. 2). I may have been turned somewhat sideways, with my left side partly toward the table. All I remember regarding the explosion itself is hearing a bang and then seeing a tremendous flash. I think it was at my right. My best guess would be that it was the in-line mixer. I ran out of the bay. At first I thought my clothes were on fire, then I realized that they weren't. I saw Bob Moorman getting out of a truck up on the road and I called for help. He stood there petrified at first and then came over to help me.

"As far as the possible causes of the accident are concerned, I think it had to be either the in-line mixer or the pump, probably the in-line mixer. Most likely either that impeller hit the wall and caused a spark or something in the packing caused an ignition. Now it seems very improbable to me that the impeller would chew through the Teflon because I think the air stirrer would be stopped before that could happen. I tried to observe whether the stuffing box was overheating, but with the process materials at 170^{0}F it's pretty hard to detect any change in temperature. The stuffing box and the mixer were hot already. I don't think it was anything unusual about the propellant itself which caused the accident. The casting was proceeding very smoothly and any change in the material would have been observed by Ivey. Also, any change in the viscosity of the material could have been detected from the speed of the air stirrer. None of these things took place."

APPENDIX C

The following are statements of Chemical Engineering Section personnel and other personnel who were near the scene of the accident which occurred on March 28, 1958, in the Chemical Engineering Section. Statements were taken beginning at approximately 2:45 p.m. on March 28.

Richard Gerges, Head, Chemical Engineering Section

"I was in the Building 7558 in the corridor when I heard a medium sized explosion and I immediately looked over to Building 7595 to see if anything had happened over there. I didn't see anything right away, no evidence of people moving about. A little later I heard another puff and explosion and I saw considerable smoke pouring out of one of the roof ventilators in the building. I immediately went to the telephone and called the operator and told her there was an emergency and asked her to send fire trucks and ambulances. She immediately started notifying people but asked me to stay on the telephone. I stayed on the telephone and kept looking out the window. I am confused but I think there was another explosion while I was on the telephone. Shortly after that, I noticed Dick Meinert come staggering out of the building on some boy's shoulder. I don't know who that was. So I immediately told the operator we needed the ambulance in a hurry. About this time other people started pouring out of the building. The smoke had gotten a little bit worse and then it started clearing away. Shortly after that I noticed several people carrying an injured man from behind the building. I couldn't tell who it was at the time. I was still on the telephone. Just about the time the injured man was carried out of the building, the fire trucks pulled up and in perhaps two minutes they were followed by the ambulance. (By the way, the first explosion occurred around one o'clock p.m.) About this time, the operator told me she had notified everyone so I hung up the phone and ran over to Building 7595. I checked the condition of the injured man. Mr. Meinert had already been put into a vehicle for

transportation to the infirmary. Mr. Corder was on a stretcher severely injured. We went to get fire blankets to cover him for shock and about that time the ambulance pulled up. I then went into the east ramp of Building 7595 to make sure no one else was in there and noticed that the door to the ten gallon mixer bay was on fire. I tried to put out the fire with a carbon dioxide extinguisher but could not get close enough for it to be effective. The firemen by that time were in the ramp and said they could put it out with a fire hose. Which they did. We made sure no one was in the building and instructed everyone to keep away from the building. There was a sound of water rushing into the ten gallon mixer bay. It is believed that this is the automatic sprinkler system. We let this run. We asked Mr. Tuck and Mr. Whitworth to turn off the steam and electric power to the building. They turned off the steam and the electric power to the north end of the building but could not turn off the power to the south end of the building without endangering themselves, so we told them not to do it. We kept everyone across the street at Building 7558 for two hours. Then Mr. Foster and I went over to make certain that the fire was out and that there was no propellant exposed to heat. There was a motor in the casting pit surrounded by hot water. We put a garden hose in this pit and turned it on so it would cool down. We checked the other bays, most of them contained small amounts of propellant, and decided that we should do nothing further until the next morning. We asked Mr. Dennis (Plant Engineering Dept.) to erect a sign and instruct his night watchmen not to go near Building 7595 but to keep a close watch on it all night Friday and to notify Mr. Foster, Mr. Dennis, or myself if they saw anything."

Joe Foster, Head, Propellant Development Group

"When I first knew about the fire, Gerges was calling emergency. I ran down into the area and saw Meinert, who immediately told me that Corder was still in there. The building was full of smoke and you couldn't go in. Still quite a bit of noise and burning. Then I went around to the east side of Building 7595 and Corder was outside approximately ten feet away from the building lying down. He was directly outside the bay where the mixer was. I could look in the bay and still see signs of burning and all this noise. I then decided that it would be better to try to remove Corder away from the immediate area. A stretcher was obtained by one of the assistants and then I think three others besides me went down and picked Corder up and carried him back to the road and there we stayed. He was covered with our coats and there he stayed until the ambulance picked him up. By the time we had gotten Corder up to the road, the fire truck was there or shortly thereafter. The smoke had cleared out sufficiently in the building so we could look into the ramp and we saw no signs of a large fire. The door was still burning and a scrap explosives can was burning. We had firemen spray water on to the door and into the bay adjacent to it where the motor that was being cast was located. They continued to spray water into the two bays and on the scrap explosives can for twenty to thirty minutes and we evacuated the area to let things cool down before returning."

Charles Ivey, Laboratory Assistant

"I was sitting in the next bay on the left. I was sitting there holding the hose casting the Jato. That was when the first explosion occurred and I headed for the nearest exit, when I heard the first explosion. I was about halfway down the hall when the next one occurred and I turned and looked and it just about knocked me down - the concussion of the second one. So I went right out of the front of the building and I

heard Meinert call for help. I couldn't see him for all the smoke but I think Mr. Moorman was standing there and I guess we saw him about the same time. We started after him but fire started in the bay and we couldn't go in for a few minutes and we went down and got Meinert but we couldn't find Corder. There was still too much smoke to see him. By that time Foster had gotten there. The smoke lifted, then we saw Corder. We got the stretcher and went down and got him and brought him up to the road and that is about it. (In reply to questions by Dr. Brown about the concussion of the first blast, Ivey said) You could feel the concussion from the first blast but it was very light compared to the second. Now the second one was terrible."

Doffus Wales, Laboratory Assistant

"I had just stepped to the door of the mixing bay that Corder and Meinert was in. Just as I got to the bay, Corder came in and I turned around and left. I had gotten back on the ramp - three or four steps from the bay door when it went off. I tell you I didn't hear anything. The next thing I knew I was getting up off the ramp. It knocked me down. I didn't hear but one blast. When I came to myself to know what I was doing, I was coming from "B" Building (Bldg 7596). I don't know how I got there. I started helping get Corder out. Joe Foster, Gayland Hargrave, Robert Adcock and Orval Howard were there when I came up. I didn't see Meinert. I helped put Corder on the stretcher and helped carry him to the door and helped put him in the ambulance. (In reply to questions by Dr. Brown about what he saw in the building where the accident occurred, Wales said) All I noticed was that the old box on the wall where we keep the tools was burning."

Gayland Hargrave, Laboratory Assistant

"I was on the ramp between Building 7595 and Building 7596. I heard the explosion, the first one, so I continued on to Building 7596 and by the time I got there, I heard the second explosion. I looked out the door and saw Meinert leaning against the sump. I went on out of Building 7596 at the front and came on up the road up here to Building 7595. Bob Moorman had Meinert on out and I came on out of Building 7595 to the road. Adcock came on around too. We were looking for Wales. We knew he was in there somewhere. We went to the door where the cafeteria was and called him and he wasn't around and we came back around to the front of Building 7595. Wales was there and they had already gotten Corder then. When I looked out of Building 7596 I couldn't see Corder. The smoke was so bad you couldn't see the building."

Orval Howard, Laboratory Assistant

"I had been over at the magazine area and started back and was at the Extra Hazardous Building and I heard the first concussion. Adcock was driving and I said, 'There goes a mixer.' We were poking along and he sort of stepped on it then and we came over here and I said, 'Don't leave this truck in the road and block it,' and we pulled in at the road of Chemical Processing where the truck is setting now. I jumped out of the truck and met Meinert and Bob Moorman. Bob was leading him. Moorman said, 'There is someone else in the building.' I didn't wait to see how badly Meinert was hurt, so I went running on down there to see what I could do. I looked down the side of the building and saw Corder lying on the side of his face. By that time, Joe Foster was there and Joe says, 'Get a stretcher.' There was one on the inside of the door down there and I went in there. It was so smoky I could hardly see but I knew where it was setting. I felt my way to the stretcher box and jerked the stretcher out. Joe and I carried it to where he was lying.

By that time, Doffus Wales came running up, so we put Corder on the stretcher and brought him up to the front of the building and set him down. Someone says, 'Get something to cover him up with,' so I went all the way to "C" Building (Bldg. 7597). I knew there were some blankets there. Pretty soon the ambulance came."

Robert Adcock, Laboratory Assistant

"I was with Howard coming back from magazine area and in front of the cycle house and saw the smoke. We came on down here and when we got here they had Meinert. Hargrave and someone else were leading him and I sat down on the truck. I asked Hargrave where Wales was and he said he was in there. I came down to the end of the building and opened the door to let out some smoke and yelled for Wales. I didn't go in. I didn't hear him and he never did answer. I came back to the road and he was coming from "B" Building (Bldg. 7596). I went in the building later on and saw one door burning. It was after the ambulance was gone."

Robert Moorman, Stores Supervisor

"I was just turning in the little road just to the east of 7570 checking the building numbers with two fellows from Post Engineers and I heard an explosion and I looked back there and saw Meinert running around in circles with his arms up. I though his eyes might be out. I went over to him. I asked the fellows from Post Engineers to call an ambulance. Then I saw Corder and I don't know whether he fell out the door or not. Then I stayed with Meinert. I didn't notice any other explosions."

L. C. Henson, Post Engineers Employee

"We were sitting in a pick-up truck inventorying real property. (Mr. Adolph Smith also of Post Engineers was in the truck.) We were

sitting there with Mr. Moorman and he was instructing us as to real property, etc. We heard the first explosion immediately behind us and Mr. Moorman says, 'Good gracious someone got hurt.' We looked back through the rear glass and we saw this boy who had been injured first come staggering out toward the road from the scene of the accident. Mr. Moorman jumped out of the truck and ran to the boy. In the meantime, we were instructed to go call an ambulance and we did. We went to the gate. About that time the second explosion - about 30 seconds or so between them - occurred. That was when the second victim came out the door. He was blown completely out the door the way we saw it."

APPENDIX D

IN-LINE MIXER

Description of New Equipment and Modifications[1]

1. New shaft made to replace existing one. Fabricated from 5/1y in. 303 stainless steel bar to same dimensions as old shaft with the exception of using a pin joint between mixer blade and shaft instead of set screw previously used.

2. Threads on 3/4 in. hex bearing retainer machined down to "clear" female threads in main mixer body. Exact dimensions on I.D. of female threads and O.D. of machined surface not measured by machinist.

3. Two aluminum brackets 180^0 apart were bolted to the sides of the 3/4 in. hex bearing retainer, 1/4 in. from the front shoulder. A clearance hole (#19 drill) was drilled in each extended flange and corresponding holes tapped into the mixer body. Two screws, #8-32 size, were used to assemble the bearing retainer to the mixer body. Tightening of these screws applied a force on the bearing for sealing purposes.

4. Tube end adaptors removed and smaller I.D. nips welded in place. Ends cut down to allow 1/2 in. I.D. plastic tube to fit over O.D. of adaptor. This modification was done at some unknown prior date to above three modifications.

[1] These notes describe changes made to the in-line mixer shortly before the explosion.

APPENDIX E

Repair of Damage to Ramps and Bay H - Building 7595

Conduit	$ 50.00
Light Fixtures: 4 tube, Class I, Group D, Fluorescents	1,200.00
Electric Power Outlet	30.00
Electric Switches	45.00
Thermostats, Pneumatic	50.00
Exhaust Fans	120.00
Pipe	50.00
"I" Beam	75.00
Roof	140.00
Doors	140.00
Lead Flooring	40.00
Paint	80.00
Total Material	$2,020.00
Labor Estimate	$1,185.00
Total Estimate	$3,205.00

The cost estimate outlined above is for structural damage done and does not cover any cost of damaged machinery and accessory equipment.

Equipment

Sigmamotor pump model T-4 with 1/2 H.P. motor and transmission	$ 650.00
Tachometers, three @ $30/ea	90.00
Small air motor for in-line mixer	50.00
Agitator, baffles, drive assembly, motor and thermowell unit for 10 gallon mixer	1,200.00
Air operated flush-bottom valve	200.00
In-line mixer	45.00
Vacuum trap	80.00
Two tables (one w/vibrating top)	250.00
Pressure relief valve and pressure regulating valve	85.00
Cu-Constantan thermocouples (3)	15.00
Tygon tubing	25.00
Misc. tools, safety cans, trash cans, rubber tubing, clamps, and ring stands	95.00
Total	$2,785.00

Shop Time for Equipment

Clean mixer and replace lid	20 hours, $4.50/hr.	$ 90.00
Pressure test mixer	4 hours, $4.50/hr.	18.00
New insulation for mixer	3 hours, $4.50/hr.	14.00
Clean existing pump	8 hours, $4.50/hr.	36.00
Mount new pump	4 hours, $4.50/hr.	18.00
Plastic labels		30.00
Guards for v belts on pumps	11 hours, $4.50/hr.	50.00
Mis. installation and cleaning		100.00
Total		$356.00

Total Estimate Equipment & Shop Time for Equip. $3,200.00

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